Electrostatic Energy and Potential

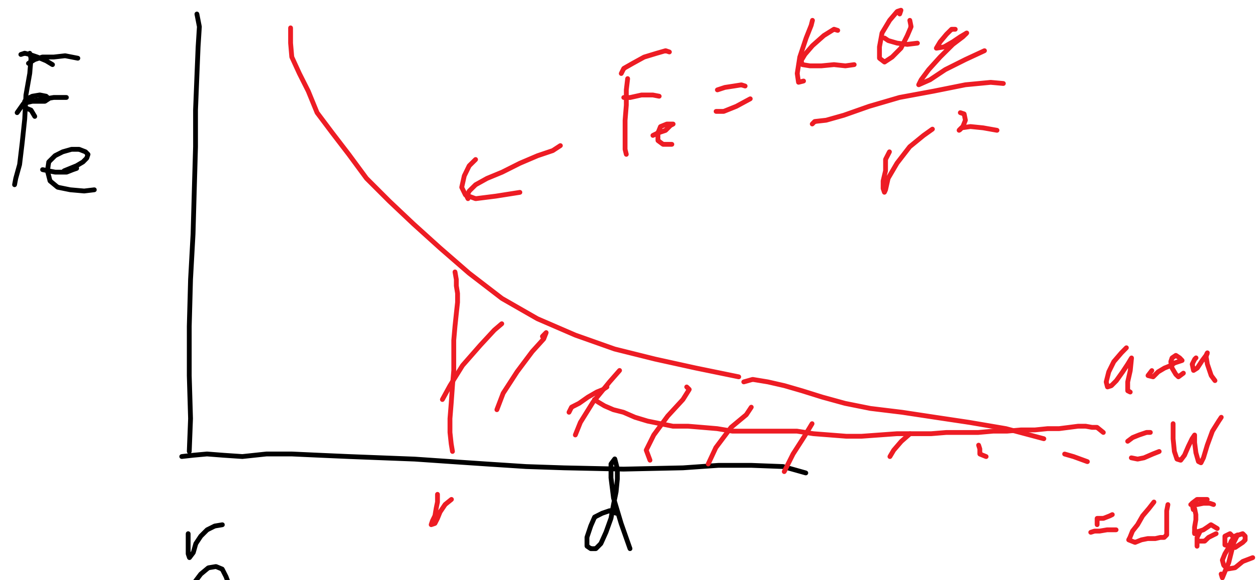
Electrostatic energy, E_e (don't confuse it with E electric field strength, F_e/q)

Derive equations using work-energy theorem

$W_e = \Delta E_e$

Work required to move a charge q to that point.

For two point charges, Q and q, the electrostatic energy is the work done moving q from infinity to a position, r, away from the centre of Q.



$$W = \int_{\infty}^{r} \frac{kQq}{r^2}\, dr =$$

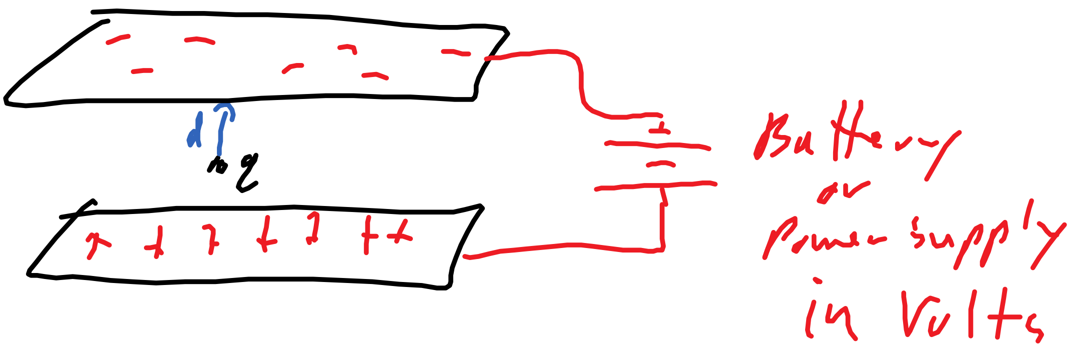
$$E = +kQq$$

$$E_e = +\frac{kQq}{r}$$

$$W = kQq\left(\frac{1}{r_f} - \frac{1}{r_i}\right) = \Delta E_e$$

for set uniform field $E = \frac{F}{q}$

$$W = Fd = Eqd = \Delta E_e$$



What is Voltage? (also called Potential)
Electrical energy per unit charge.

$V=E_e/q$

For a point charge

V=kQ/r relative to zero at infinity

Potential difference, V=kQ (1/rf -1/ri)

(like gravitational potential, $V=E_g/m$)

For uniform field

$V=E_e/q$ = Eqd/q =Ed

You can use this to determine the electric field between parallel plates with potential difference, V, a distance d apart.

E=V/d

Equipotential lines - show where the voltage is constant in space.

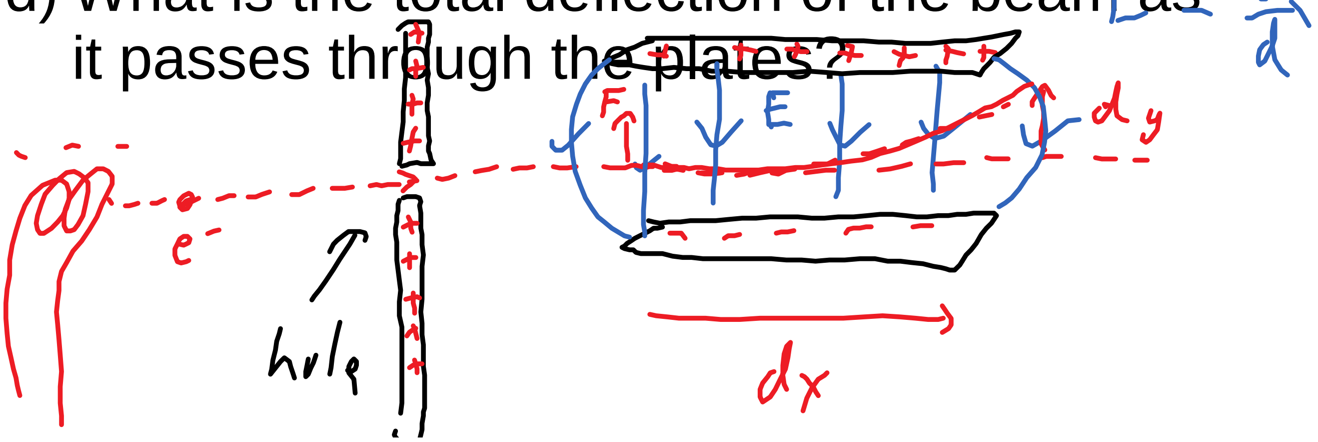
Rules-
Always parallel to conductors
Always perpendicular to field lines
The spacing is determined by the electric field
V=Ed for uniform field or kQ/r for point charges

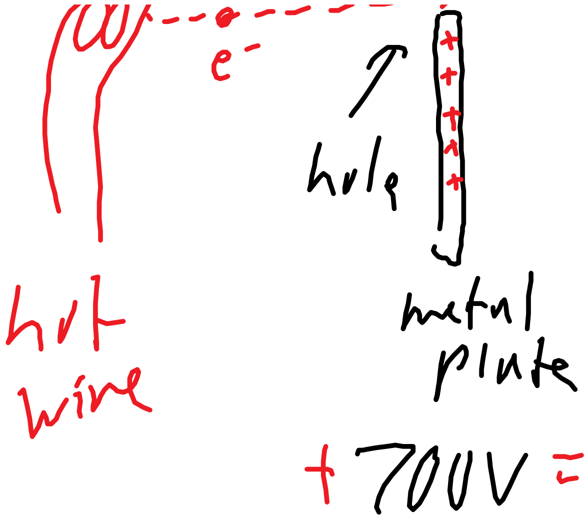
1. A 6.0 micro coulomb charge is 20.0 cm from a -3.5 micro coulomb charge.

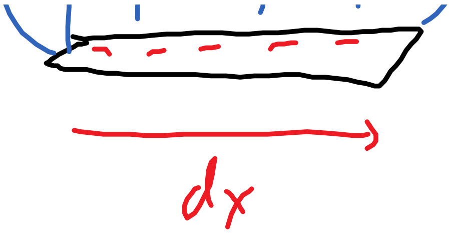
a) What is the force between the charges?
b) What is the electrostatic energy of the -3.5μC charge relative to zero at infinity?
c) What is the field strength at the midpoint between the charges?
d) What is the potential at the midpoint between the charges
e) What is the field strength and potential 5.0 cm above the midpoint?
f) How much work is done moving the -3.5μC charge 5.0 cm closer?
g) Draw field lines and equipotential lines.

2. A cathode ray tube has an accelerating voltage of 700V before going between two parallel plates, 0.50 cm apart, 4.0 cm long and 20.0V of potential between them.

a) What is the speed of an electron after being accelerated by 700V?
b) What is the field strength between the parallel plates?
c) What is the acceleration of the electron between the plates?
d) What is the total deflection of the beam as it passes through the plates?



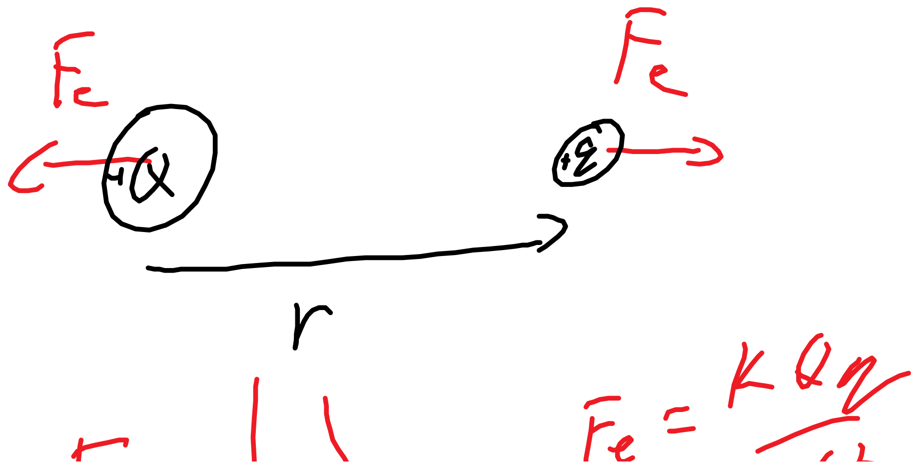


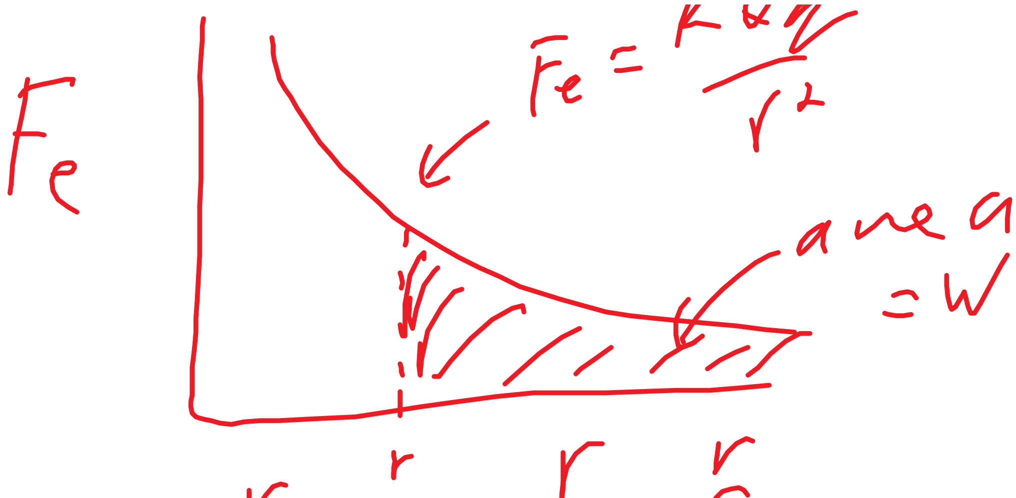


Electrostatic Energy, E_e, and Potential (Voltage) V

Derive expressions for energy using the work-energy theorem.

Work done against the electric field = change in electrical energy





$$\Delta E_e = W_e = \int_{\infty}^{r} F_e \, dr = \int_{\infty}^{r} \frac{kQq}{r^2} \, dr$$

$$E_e = +\frac{kQq}{r}$$

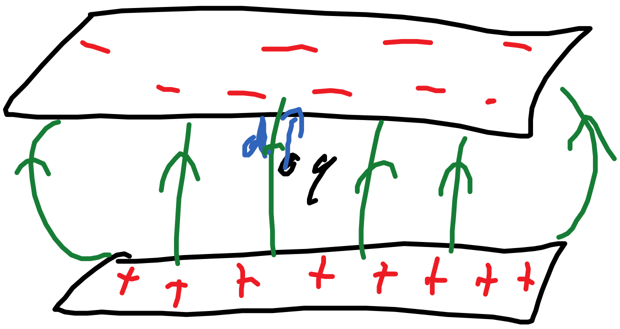
rel to 0 at $r \to \infty$

Positive because F_e is repulsive (F_g is attractive)

$$W_e = \Delta E_e = kQq\left(\frac{1}{r_f} - \frac{1}{r_i}\right)$$

For a uniform field, $E = \frac{F}{}$

- Between parallel plates



$W = Fd$

$W = Eqd$

Electrostatic Potential = Voltage

$V = \frac{E_e}{q}$ Potential difference $= \frac{\Delta E_e}{q}$

for point charges

$V = \frac{KQq}{r\,q} = \frac{KQ}{r}$

for uniform field

$V = \frac{\Delta E_e}{q} = \frac{Eqd}{q} = Ed$

$$E = \frac{V}{d}$$

field between two plates, d apart with potential V across.

Equipotential Lines

Show lines of constant electrostatic potential

Rules: don't cross

Perpendicular to field lines

Parallel to conducting surfaces